

Exploring policy options to mitigate the loss of wetlands on prairie landscapes

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The Issue

Over the past century, wetlands in North America's prairie pothole region have been lost at rapid rates. In Alberta, Canada, wetland loss is particularly problematic due to increasing urban, agricultural, and oil and gas development pressures. The issue of wetland loss is compounded by:

- (1) Lack of accurate wetland inventories;
- (2) Lack of estimates on rates of wetland loss;
- (3) Absence of wetland policies to further protect against loss.

Alberta's 1993 interim wetland policy¹ was ineffective in its "no net loss" approach, focused on wetland area. Twenty years later, the Province passed the Alberta Wetland Policy², that shifts the focus from wetland area to wetland function. This study presents an approach to automate wetland mapping, estimate wetland loss rates, and develop a wetland function assessment system founded on ecological and hydrological processes for estimating wetland function.

Study Area – The Beaverhill Watershed

The Beaverhill watershed is located in the Parkland and Boreal forest regions of Alberta and encompasses the Eastern portion of the City of Edmonton and surrounding areas (Figure 1). It is made up of a diverse mix of land types and uses, from urban, natural, and agricultural to oil and gas development. The watershed also contains large conservation areas, including Elk Island National Park, Cooking Lake Provincial Park, and Miquelon Bird Sanctuary.

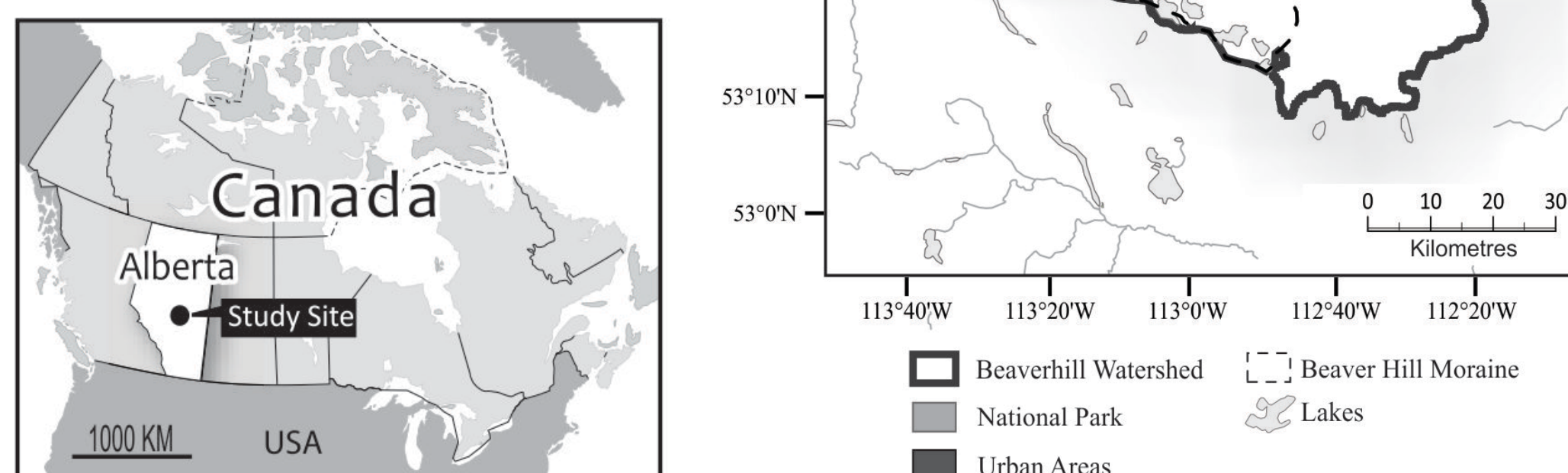


Figure 1: The Beaverhill watershed.

Wetland Mapping

An accurate wetland inventory is critical for the estimation of wetland loss rates and function. Current inventories are often incomplete, of low resolution, time consuming to create, and not-standardized³. We have created a novel automated wetland mapping method (Figure 2) that involves conducting object based wetland classification on high-resolution LiDAR digital elevation models and ancillary data, such as air photos and vegetation height, to map open water and delineate wetland boundaries⁴ (Figure 3).

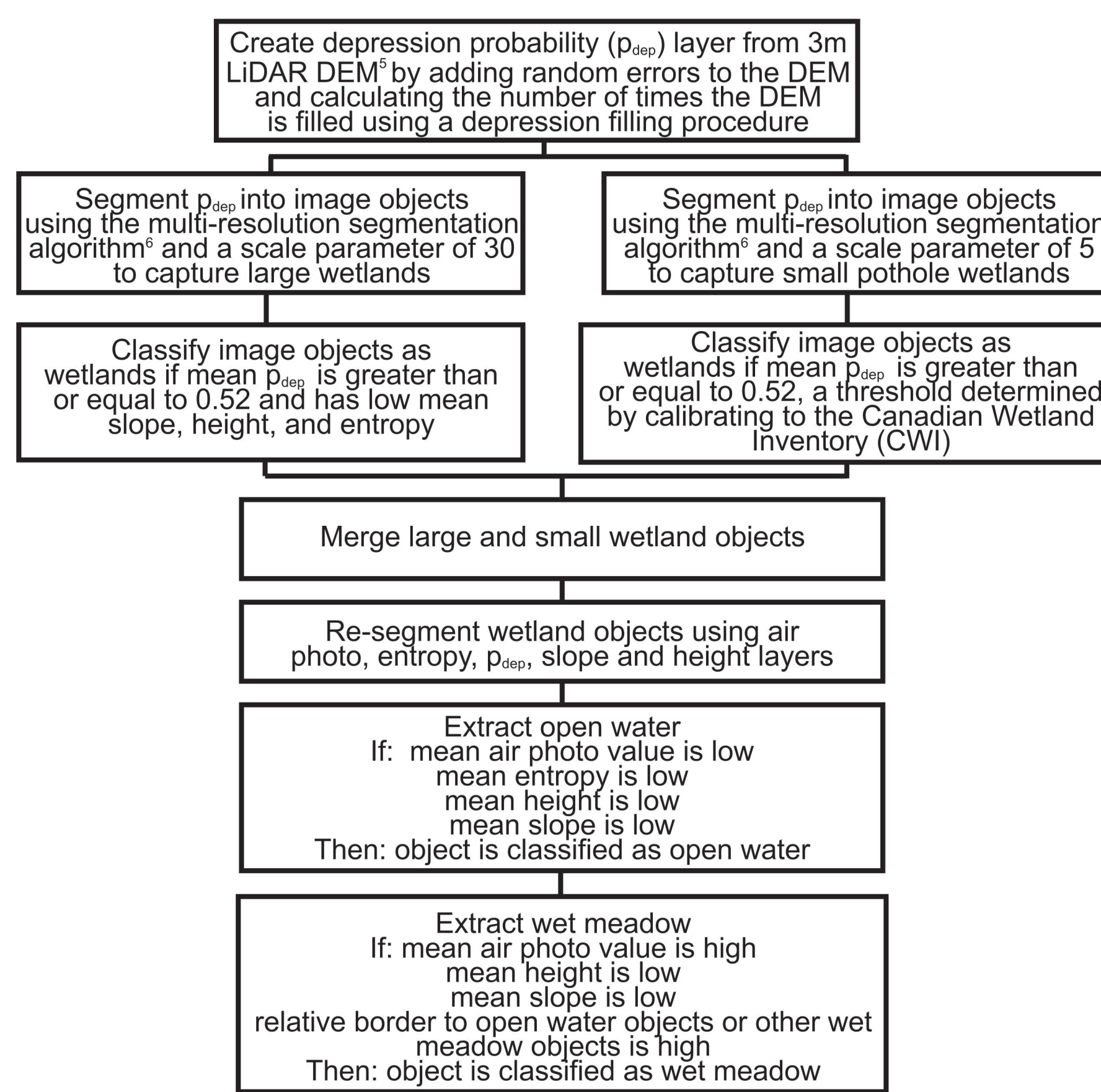
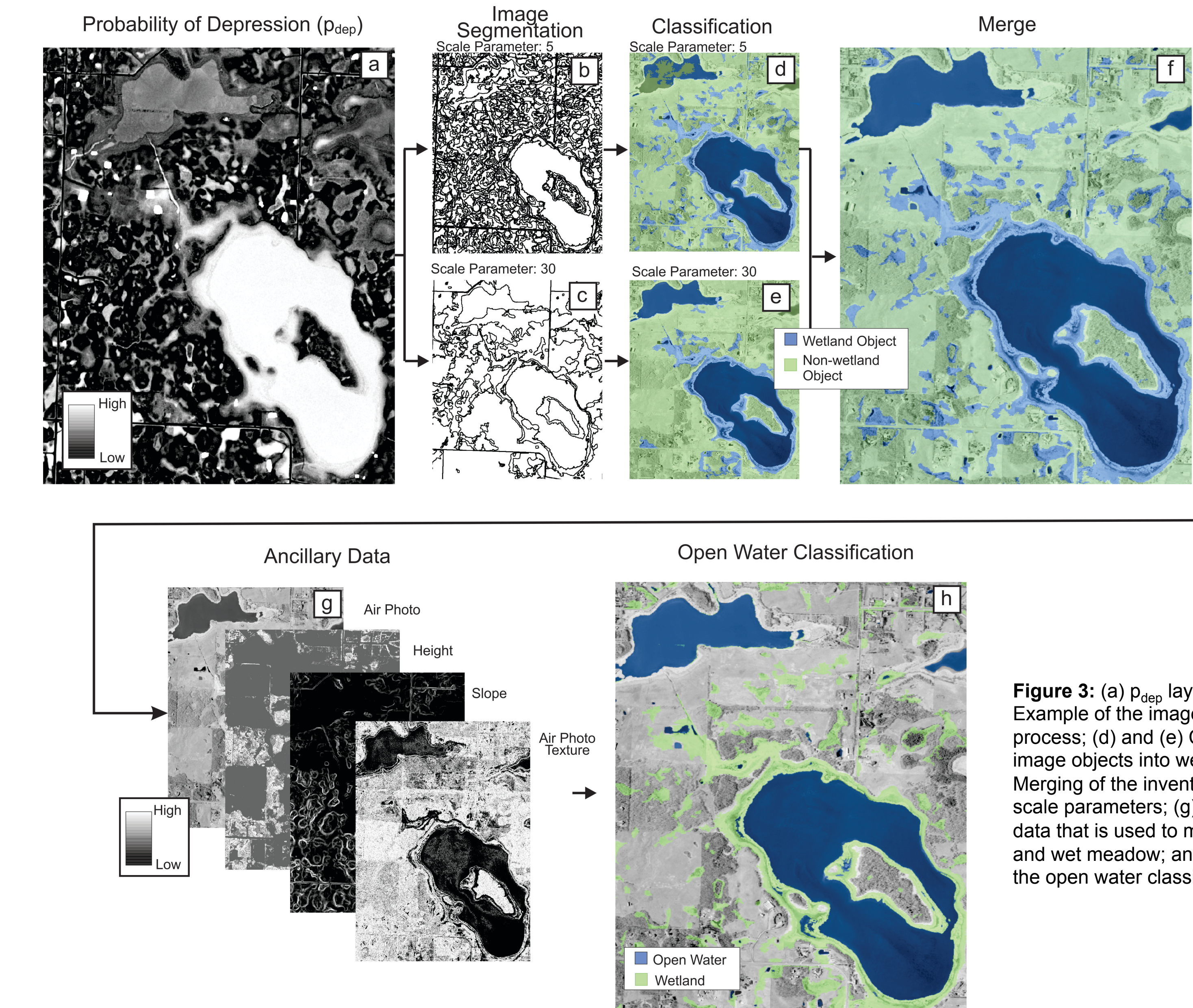


Figure 2: Wetland Mapping Methodology



Policy Potential: Having accurate, up-to-date wetland inventories allows for the presence of wetlands to be considered in the development approval process.

Estimating Wetland Loss

Using Geographic Information Systems (GIS) wetland inventories, we can estimate historic rates of wetland loss by applying an area-frequency power function. Within a given undisturbed geographic area, a negative linear relationship exists between the number of different sized lakes and the classes of lake size, when plotted logarithmically⁷. A linear change in this relationship's slope indicates wetland change, likely through meteorological/hydrological functions such as climate fluctuation. A non-linear slope change indicates wetland change that may be attributed to climate or anthropogenic functions.

Using the assumption that there is a preferential loss of small wetlands⁸, the relationship between frequency and area is expected to "break" at a maximum disturbance size threshold. In order to identify this aforementioned breakpoint, a piecewise 2 segment linear regression can be conducted. A sharper "break" indicates a greater magnitude of small wetland loss, likely through anthropogenic functions. Below this "break", wetland loss (ha) may be estimated as the area between the observed curve and an extrapolated line from the linear relationship above the threshold (Figure 4).

Results: There has been a 78% loss in the number of wetlands in the Beaverhill watershed, which is equivalent to 54% of wetland area (Figure 5).

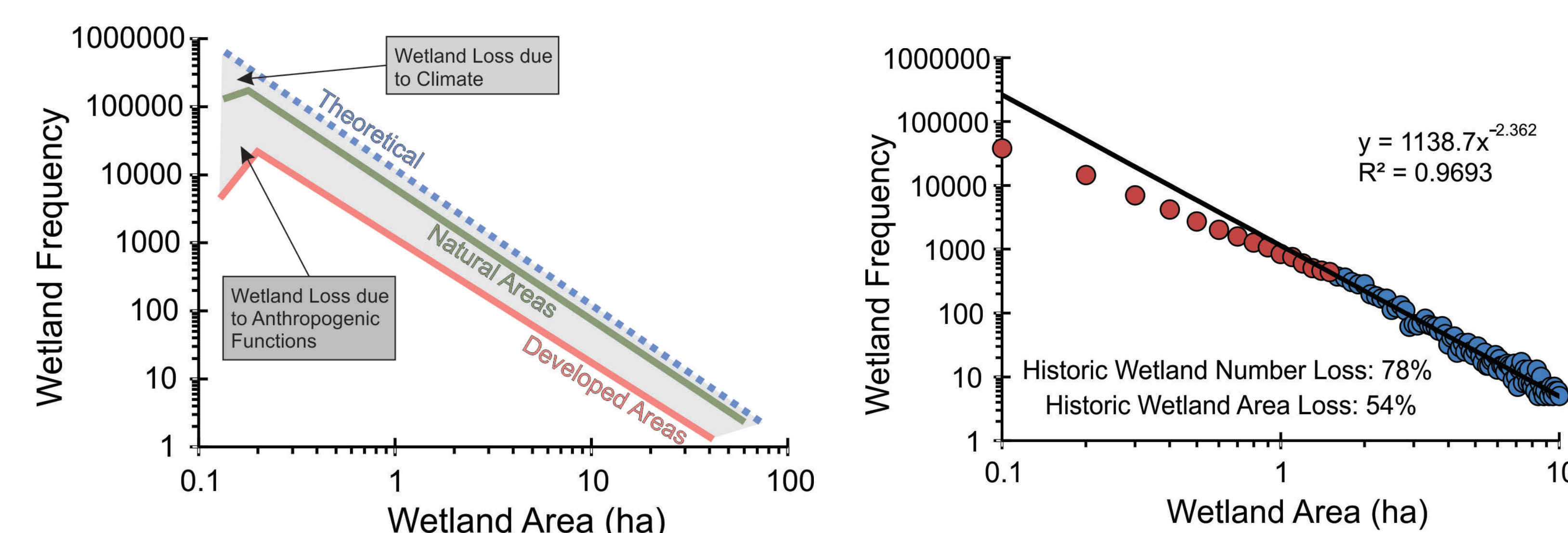


Figure 4: A conceptual model of the area-frequency power function.

Figure 5: The area-frequency power function applied to the Beaverhill watershed. The red dots are below the breakpoint of 1.5, blue dots above.

Policy Potential: Wetland abundance can be used to estimate wetland 'scarcity'. Historic loss rates can be calculated and conservation targeted to areas with high rates of loss and few wetlands.

Wetland Function Assessment System

Methods: We created a wetland function assessment system founded on ecological and hydrological processes for estimating wetland function associated with biodiversity, flood control, and pollution reduction. Indicators (Methodology, Figure 6; Indicators, Tables 1, 2, & 3) of wetland function were identified and GIS and remote sensing data and technologies were used to extract these indicators.

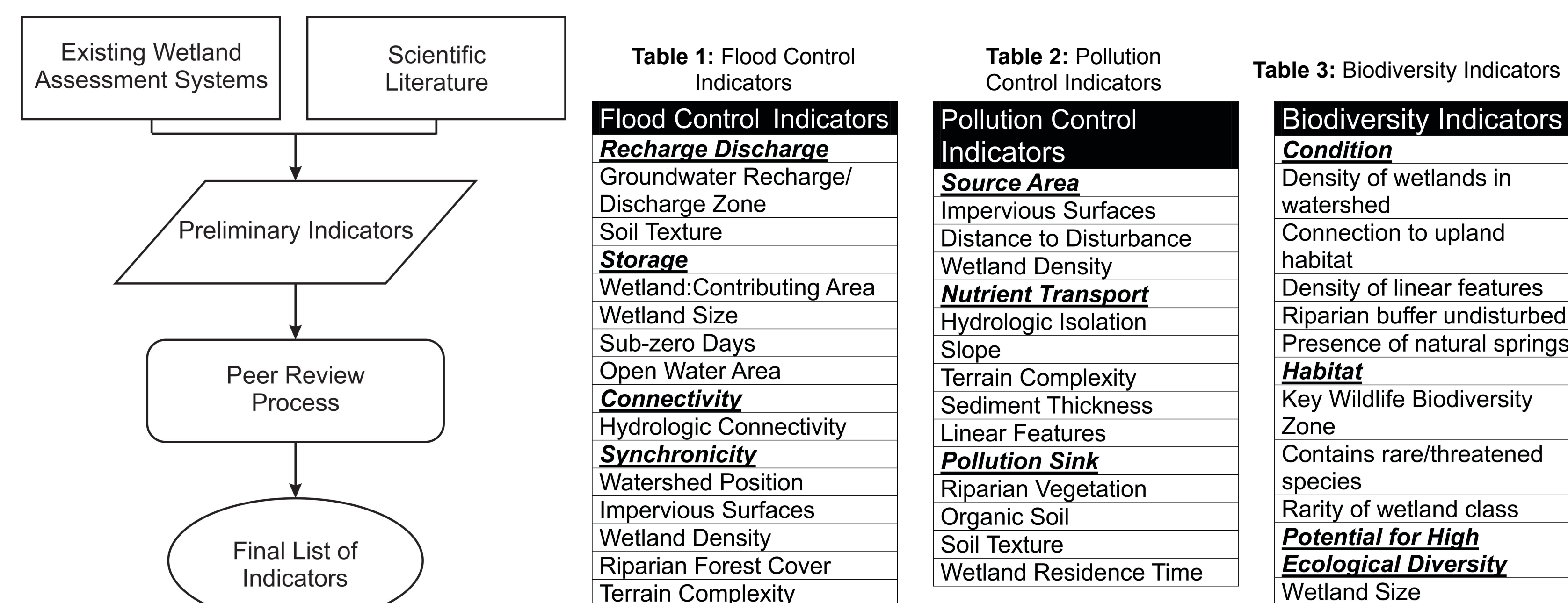


Figure 6: Indicator Creation Methods

Indicator results were scaled between 0 and 10 for standardization. Metrics were combined using a simple average of those relevant to each function producing a flood, biodiversity, and pollution control function score per wetland. The corresponding wetland scores were assigned to a class ranging from A to D; where A is high functioning and D is low functioning.

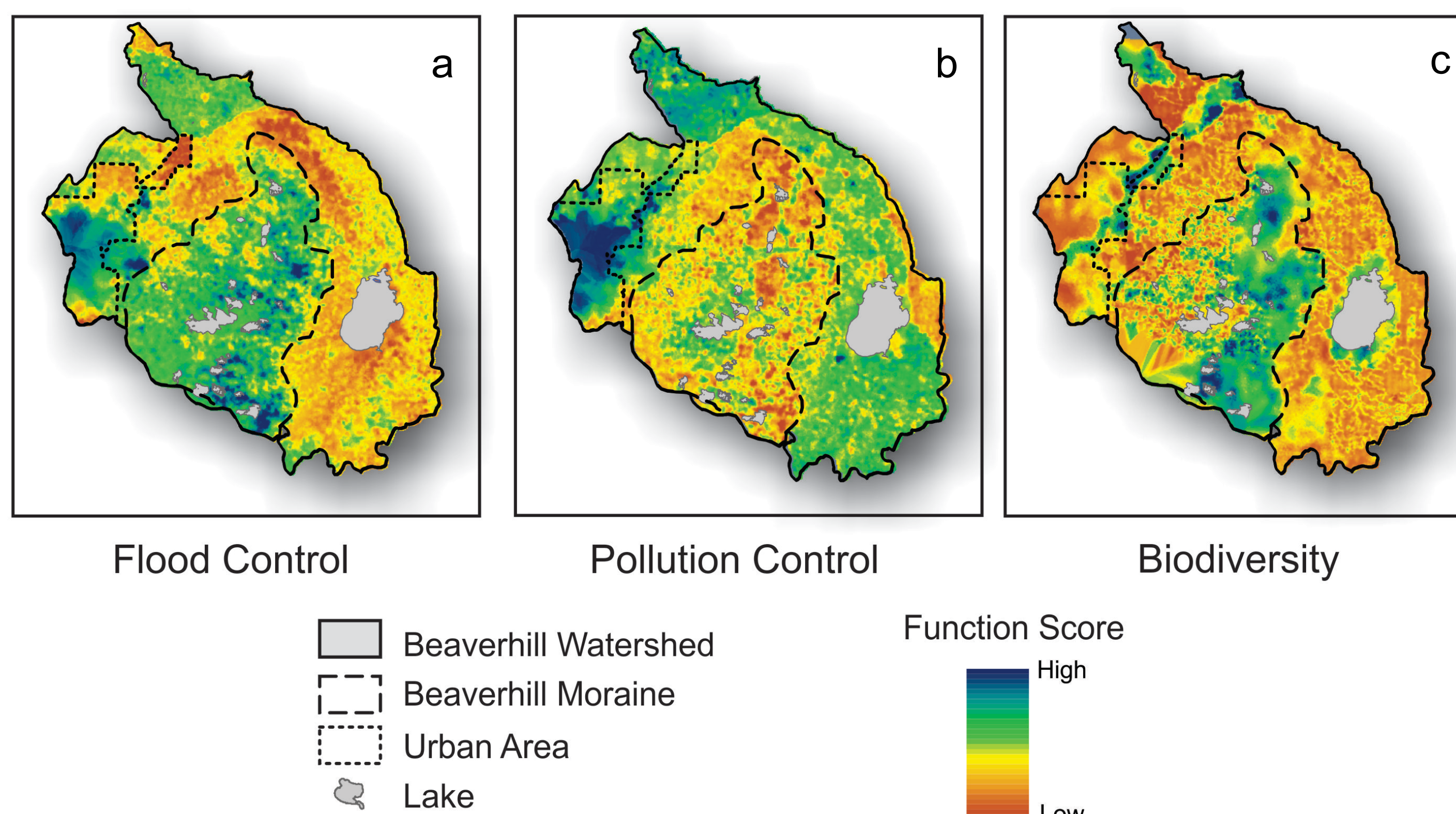


Figure 7: Resulting scores from the wetland function assessment system for (a) flood control; (b) pollution control; and (c) biodiversity.

Results: In the Beaverhill watershed, high flood control function was found in the moraine and urban areas; high pollution control function was found in the agricultural and urban areas; and high biodiversity function was found in the moraine (Figure 7). The wetland scores ranged from: Flood Control: 1.6 – 5.9; Pollution Control: 2.0 – 6.8; Biodiversity: 2.1 – 6.7.

Wetland Function Assessment System (cont'd)

Policy Potential: These results show the importance of tradeoffs as wetlands with high flood control function may be located in areas of low diversity and/or pollution control. Indicator results can be combined with historic wetland loss rates to allow policy makers to adjust thresholds between wetland function and policy objectives. Further, function scores can be used to modify compensation ratios² (Table 4).

Table 4: Proposed Compensation Ratios based on Wetland Function².

Value of Lost Wetland	Value of Replacement Wetland			
	D	C	B	A
A	8:1	4:1	2:1	1:1
B	4:1	2:1	1:1	0.5:1
C	2:1	1:1	0.5:1	0.25:1
D	1:1	0.5:1	0.25:1	0.125:1

Scenario Analysis

Conservation software (Marxan) was used to conduct 'future' scenario analyses to identify the set of wetlands across the landscape that produce the highest combined flood and pollution control score (biodiversity was not included) while meeting set conservation targets.

The 'future' scenarios:

- (1) **Environmentally Hostile Future:** Conservation target set to 10% of current flood and pollution control.
- (2) **Environmentally Intermediate Future:** Conservation target set to 50% of current flood and pollution control.
- (3) **Environmentally Friendly Future:** Conservation target set to 90% of current flood and pollution control.

Results: Wetlands in urban areas are irreplaceable and should be conserved (Figure 8). Overlaying the intermediate scenario over the conserved portions of the watershed shows us that currently the conserved areas are likely protected due to their biodiversity and recreational opportunity, as opposed to their flood and pollution control potential (Figure 9).

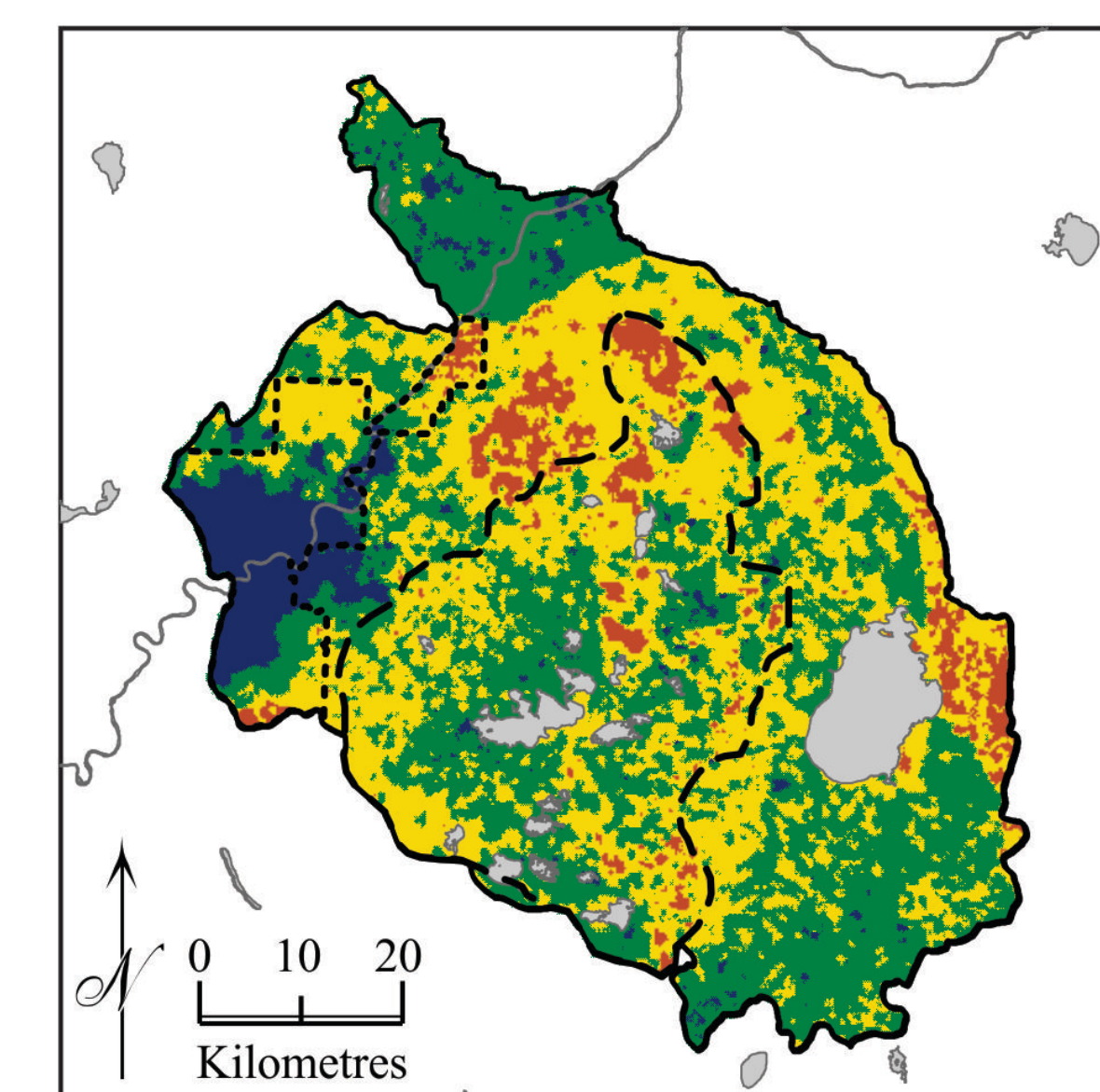


Figure 8: The results of the scenario analysis.

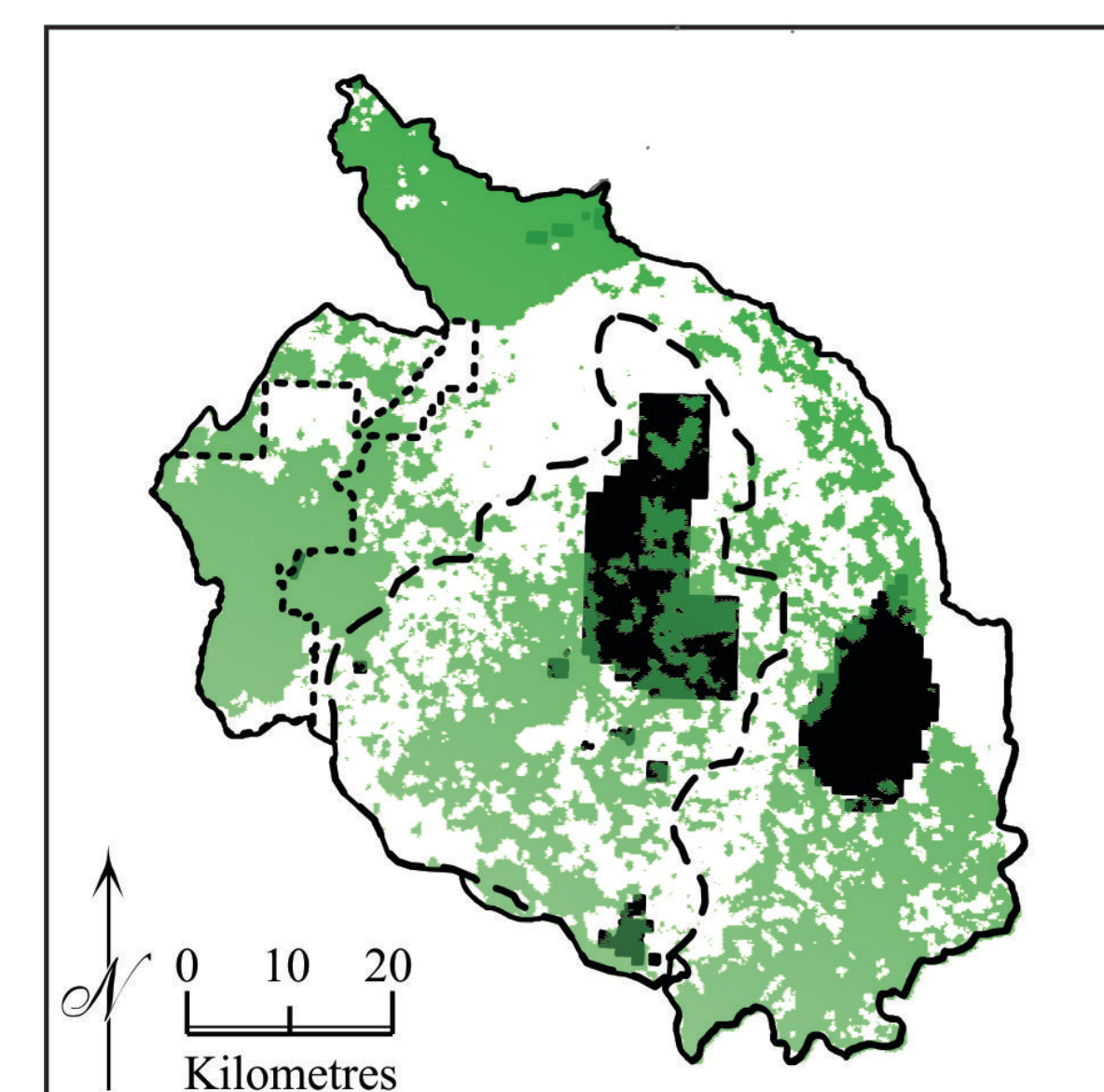


Figure 9: The intermediate future scenario results overlain onto currently protected areas.

Policy Potential: Scenario analysis shows that wetlands with high ecological function may not be the same wetlands with high hydrological function, thus informing policy design by revealing tradeoffs that must be considered in wetland conservation.

Conclusions & Visions for the Future

- These tools provide a scientific foundation on which effective policy can be built.
- The presented policy options can be used to reduce and mitigate the impacts of wetland loss.
- Wetland loss rates indicate that land use changes and development within the watershed have resulted in a large rate and area of wetland loss.
- Scenario analyses results indicate the importance of tradeoffs and the need for future work around wetland conservation.
- Further work to explore optimal weighting strategies for the combination of indicators into an overall score for each wetland should be conducted.
- The wetland loss rate methodology should be validated using existing wetland loss estimates.
- The wetland function assessment system can be continuously updated as new science, data, and technology become available.
- It is important to remember that areas of the watershed that, due to this analysis, are deemed low priority for conservation still contribute important wetland functions.

References

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